



# ***Emerging Sensor Technologies for the Objective Force***

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# Operational Challenges

## "Division/Corps" Level - National Assets

### Locate Enemy Formations

### "Brigade" Level

#### 1. TUAV - Eye in the Sky - Comanche

- a. Over-the-horizon, all weather, wide area search capability for Bde
- b. Complement Global Surveillance in areas hampered by shadowing, foliage, CCD
- c. Obscured target detection; e.g., Tanks Under Trees
- d. Provide continuous tracking and targeting for longer range standoff weapons
  - Standoff minefield detection
  - Mission Planning and C2

Global/  
Theater

~100 km

~25 km

### 2. BLOS Networked Sensors "Battalion" Level

- a. Fill in gaps from higher echelon Intelligence sources
- b. Extend the eyes and ears of scout with organic unmanned platforms
  - Near real time SA, BLOS threat detection and targeting
    - Maneuver Planning C2
    - Non-Combatants
- d. Prevent unintended close combat

### Extended Red Zone

### Vehicle Line of Sight (LOS)

#### 3. Manned Platform Sensors

- a. Rapid search
- b. target detection and ID at extreme LOS ranges
- c. On the Move (OTM) performance
- e. Maintain OPTEMPO, survivability through mine avoidance

~12 km

~5 km

### Close Combat/Urban

#### 4. The Close Fight and Soldier Sensors

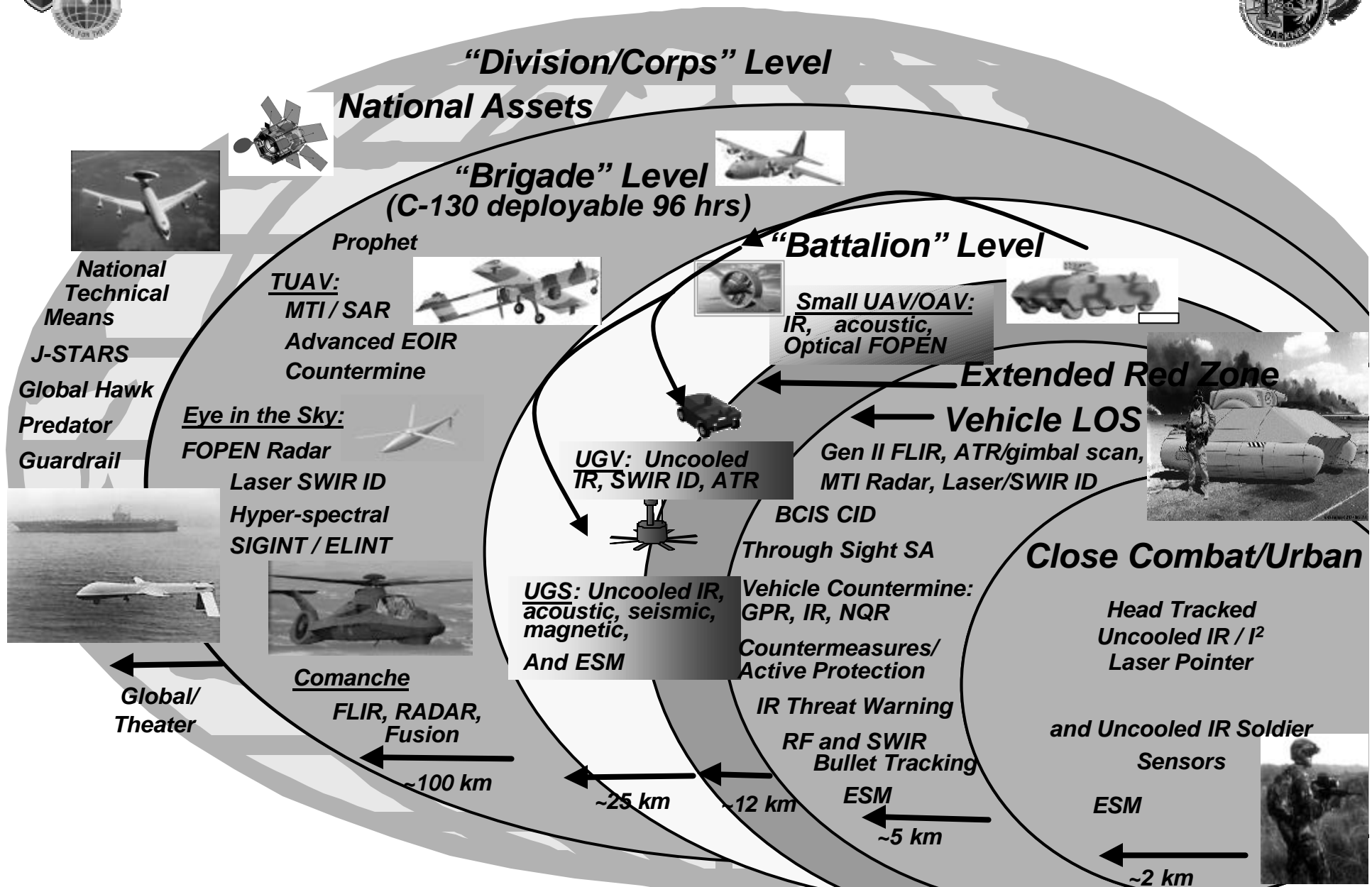
- a. Closed hatch SA and rapid response to dismounted threats in MOUT
- b. Connectivity and cooperative ID for elements of the dismounted/mounted team for fire, maneuver, assault
- e. Small, lightweight, low cost and low power soldier sensors

~2 km

**Sensor Integration and Fusion critical to Command Decisions**



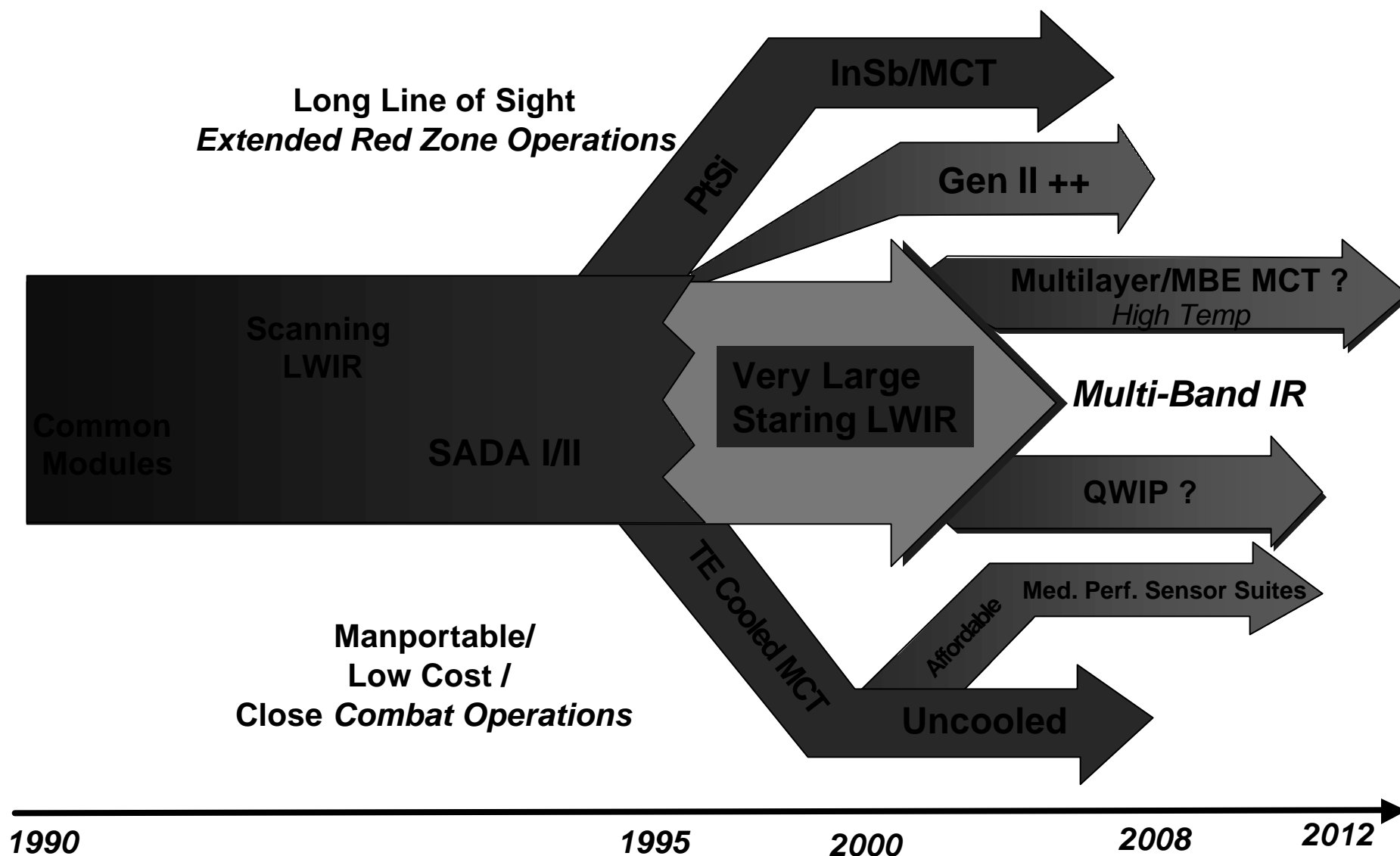
# Intelligence, Surveillance, Reconnaissance and Targeting



**Need a full range of networked sensors to meet the new requirements**



# Imaging FPA Technology Roadmap





# Objective Force Long Range Target Acquisition Sensor Requirements



## Capabilities

*Detect, recognize & identify*

*Identify range*

*Target search & acquisition*

*On the move performance*

*Target “queing”*

## From This...

Field of view

Targets in open

Half the enemy’s detection range

120° field of regard in 100-240 sec

Moderate range recognition

Manual detection/recognition/ID

## To This...

Field of regard

Difficult targets (defilade)

Beyond enemy detection

120° field of regard in 4-6 sec

Long range identification

Aided target queing/  
recognition – Through sight  
S/A hand-off

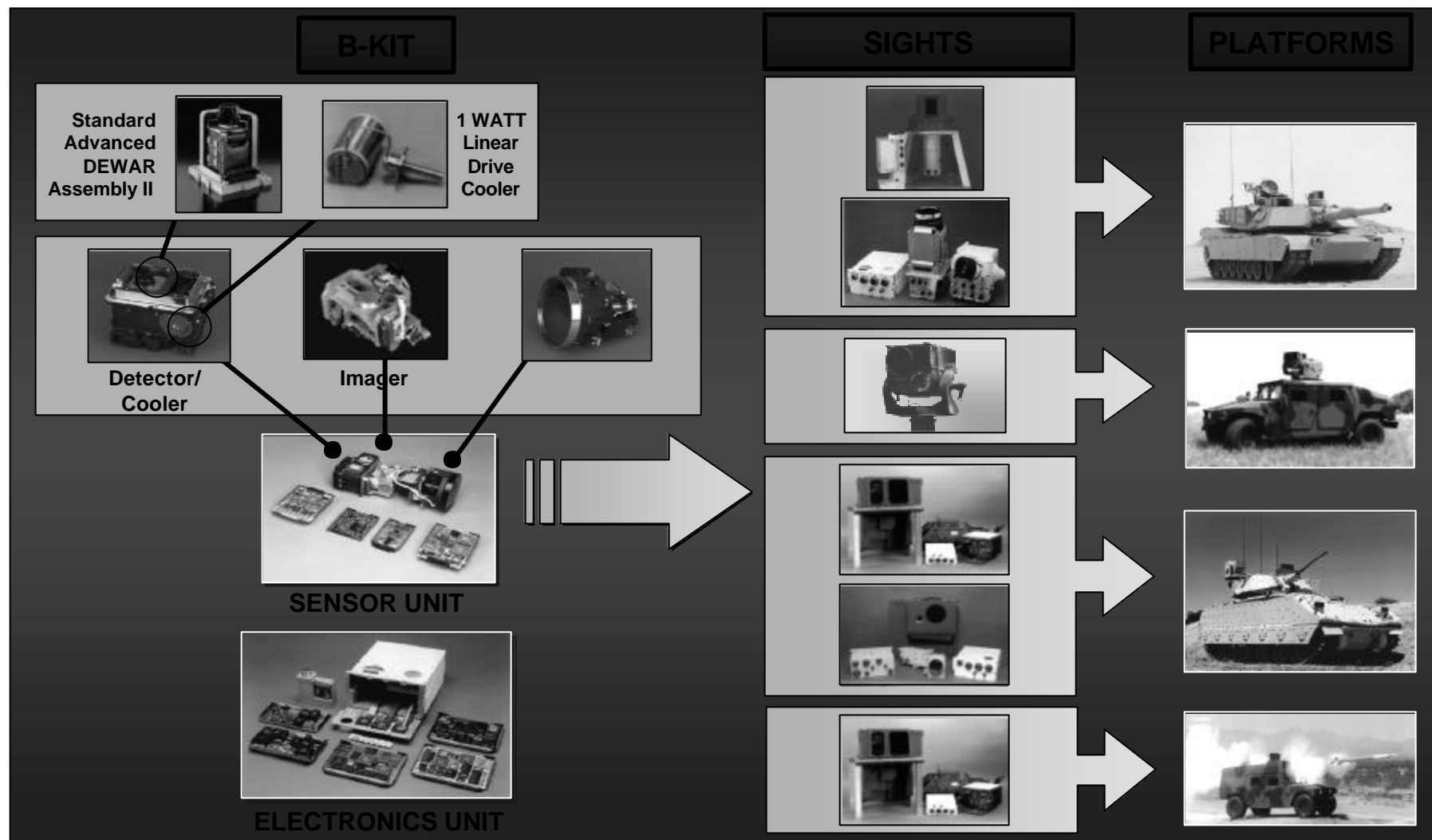
*Implement: See First - Understand First - Act First - Finish Decisively*



## HTI Rationale:



# HTI 2<sup>nd</sup> Gen FLIR was a Huge Success





# Legacy US Capability and Desired Capability

1st Dig Corps - 2008

SGF  
M1A2 Sep

FGF  
M1A1/A2

SGF  
T72MP

**Legacy Force  
(Tank vs. Tank)**

Rapid Wide  
Area Search  
(120° Gimbal Scan)

FLIR Detection

FLIR Detection

SWIR ID

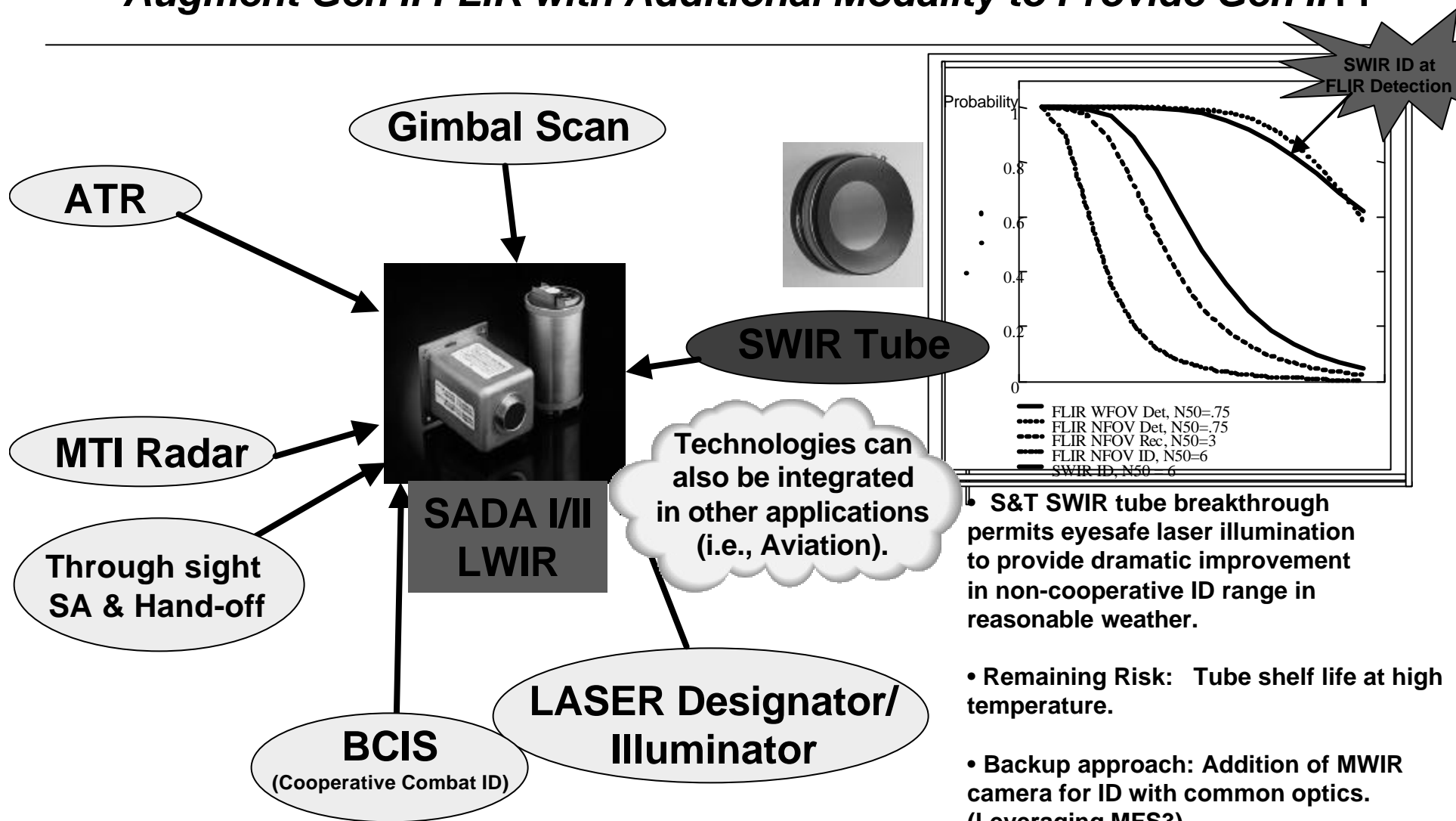
SGF  
T72MP

**OF Tactical Vehicle  
vs. Tank**

ID beyond Enemy  
Detection Range

Compensate for Asymmetric Rules Of Engagement

## Baseline Approach – Augment Gen II FLIR with Additional Modality to Provide Gen II++



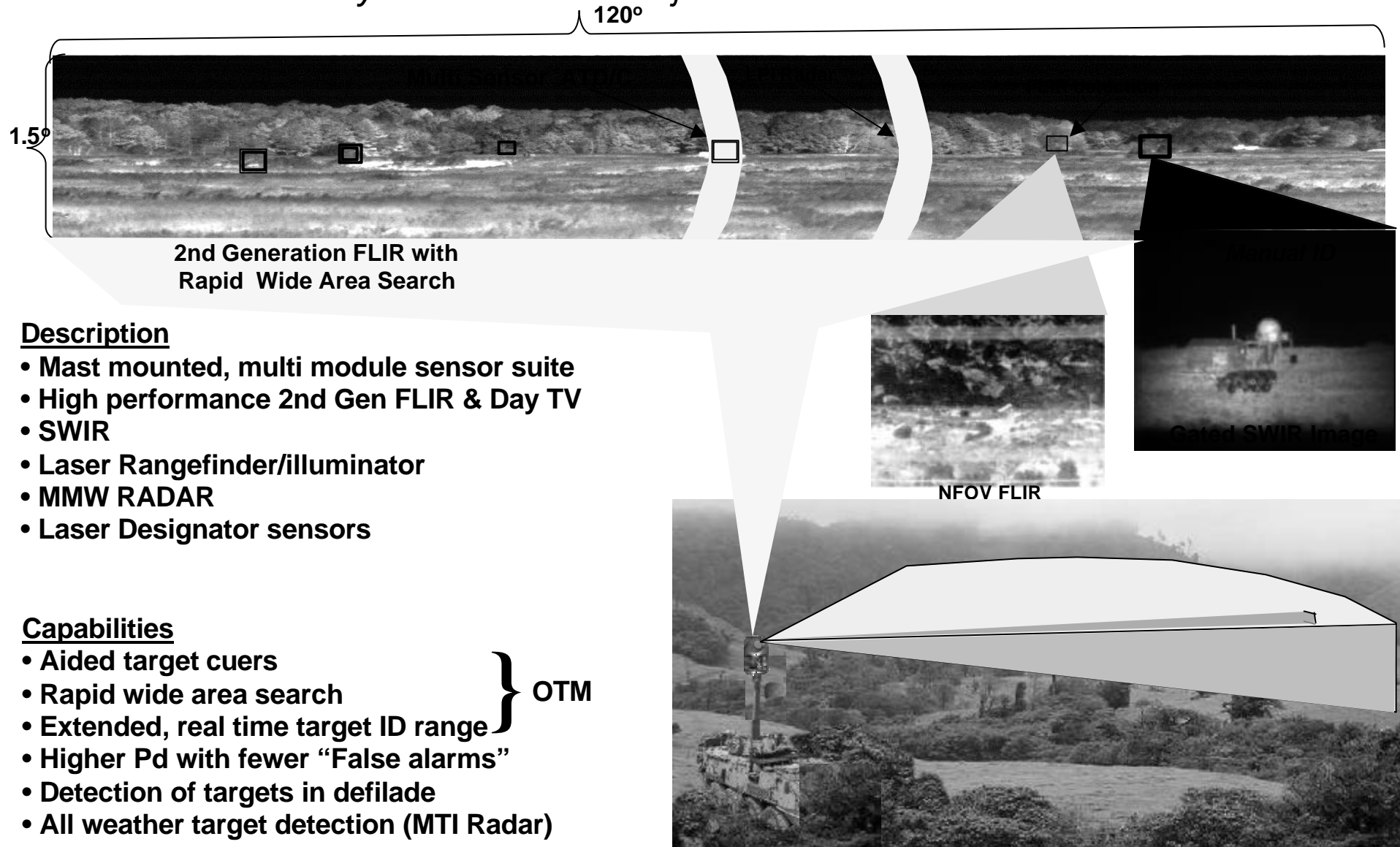
Leap ahead capability and low schedule risk through leveraging of SADA I/II investment to provide GEN II ++

**(GEN III Dual Band requires more time and large upfront investment)**



# Objective Force Target Acquisition Sensor Suite Concept

Ready for accelerated Objective Force Schedule – FY 08



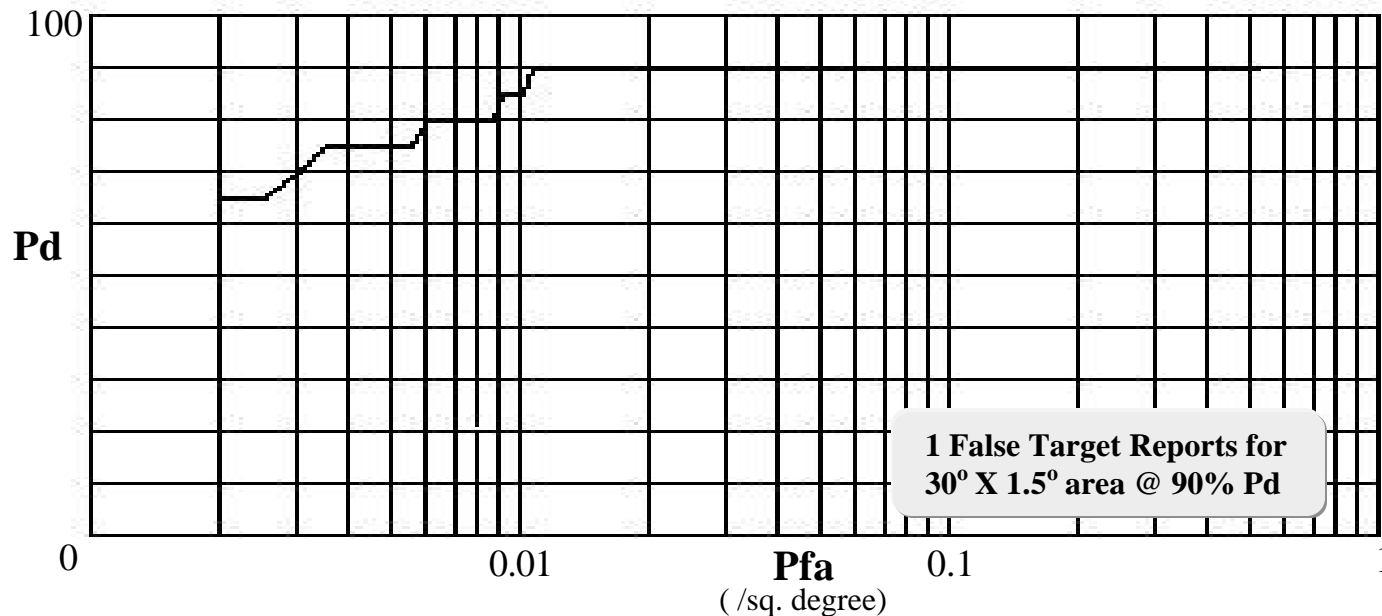
Gimbal Scan (-w-ATR) provides rapid search (4-6 sec vs. 100- 240 sec manual) needed for FCS survivability.  
Eye-safe laser illumination provides long range ID.

UNCLASSIFIED

## Wide Area Target Cueing Within 4 Seconds (*no eyes*) With Low False Alarm Rate



30° GIMBAL SCAN with ATR



**Data Collected at U.S.Army Site :** Moderate to Low clutter

**Range to Target Error:**  $\pm 10\%$

**Target Types:** Tanks, APC's, ADU's, and Trucks at various aspects

**Range to all Targets:** between 3 – 3.5 Kilometers

**Signal-Noise:** All targets ?  $T \geq 1.25^\circ C$

**Optical Access:** All targets are at least 12 lines high (NFOV)

**Northrop ATR now showing adequate performance with high resolution in NFOV**

UNCLASSIFIED

TASS for FCS.ppt Last Updated: 11-Jul-01



# Basic Operation of Laser Gated Imaging

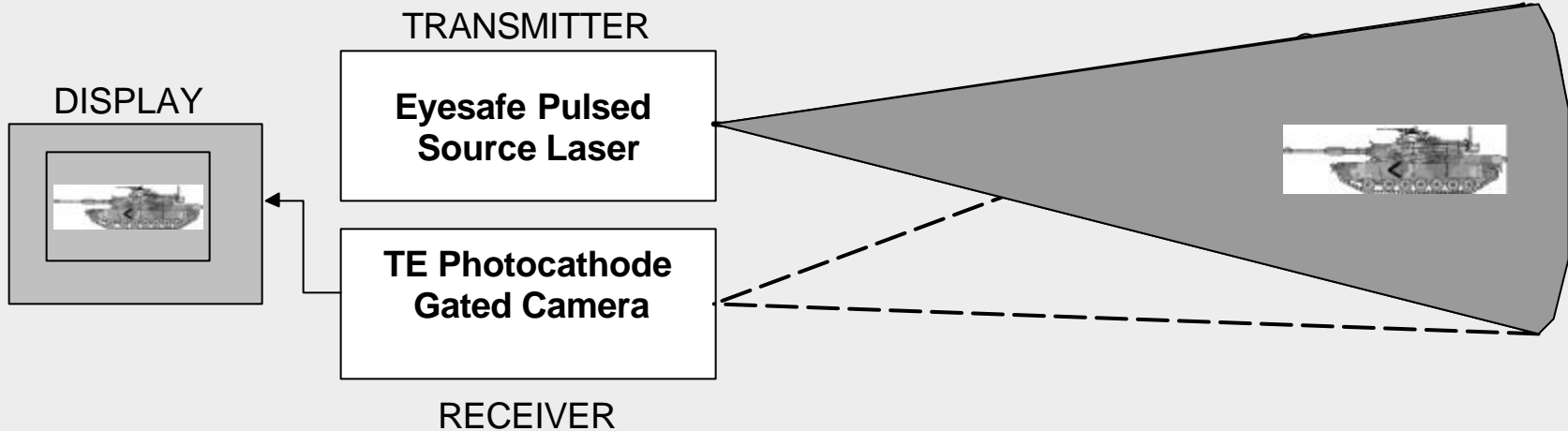


Detection of the target with FLIR,  
Using the Laser imaging system to:

- ✓ Establish Range To Target
- ✓ Adjust Beam Size And Range Gate
- ✓ Illuminate Target With Laser Pulse  
Help You Identify the Target...



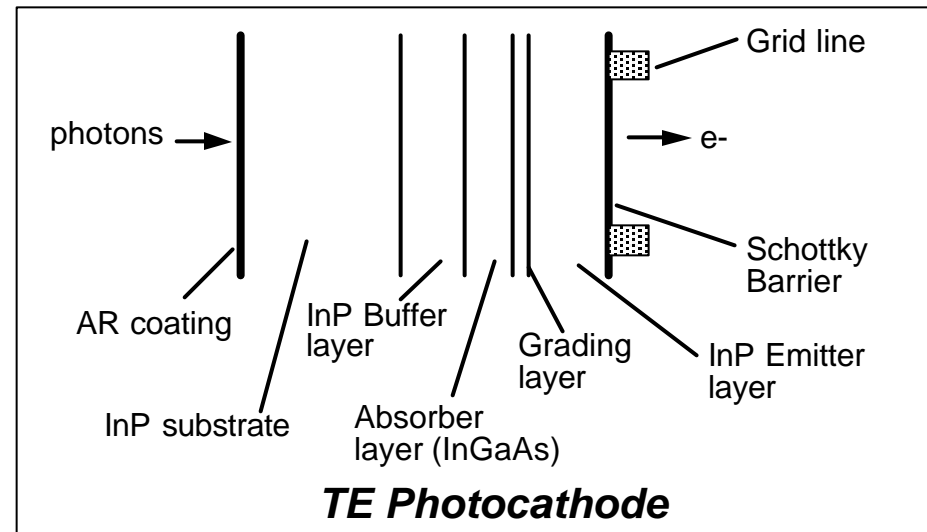
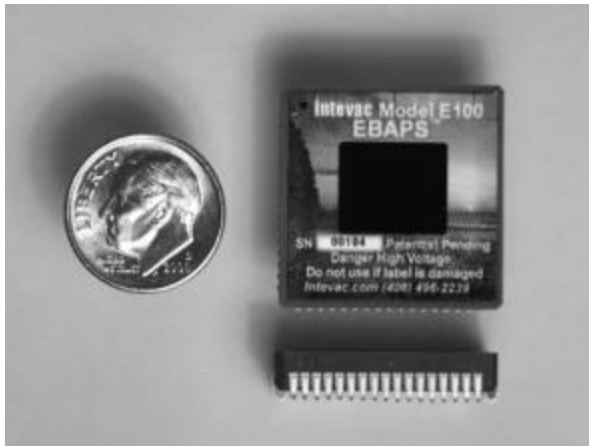
*Actual SWIR imagery*



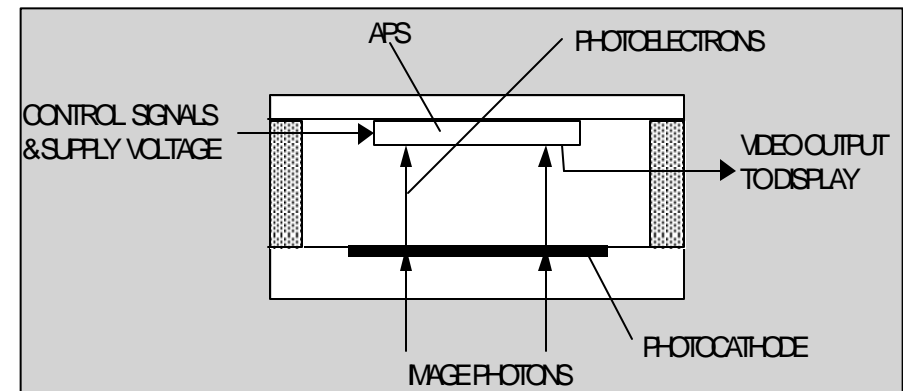
**...in less than a second**



# Transfer Electron, Electron Bombarded Active Pixel Sensor SWIR Imager (Intevac)



Photocathode	Field Assisted InP/InGaAs Photocathode
Pixel Size	13 $\mu\text{m}$
Full Well Capacity	>50,000 electrons
Array size	1280x1024
Operating Voltage	4kV (cathode-to-anode)
QE (1.5 $\mu\text{m}$ )	>25% @ 3V Schottky barrier bias
Dark Current@20°	50nA/cm <sup>2</sup>



**Improved MTF and reduced system cost required**



# Why Multicolor Or Dual Band?



Environment	Spectral Preference	
	3-5mm	8-12mm
Maritime	✓	
Arctic		✓
Long Line of Sight Ultra NFOV ID	✓ (big improvement for given aperture)	
Dirty Battlefield - Smoke & Dust		✓
Pilotage		✓
Plume Detection	✓	
Sunlit Clutter	Multicolor MWIR	✓
Rapid aided search (gimbal scan)		✓
Difficult Targets/ATR		
CCM (Laser and Flares)	Multi Color MWIR	✓

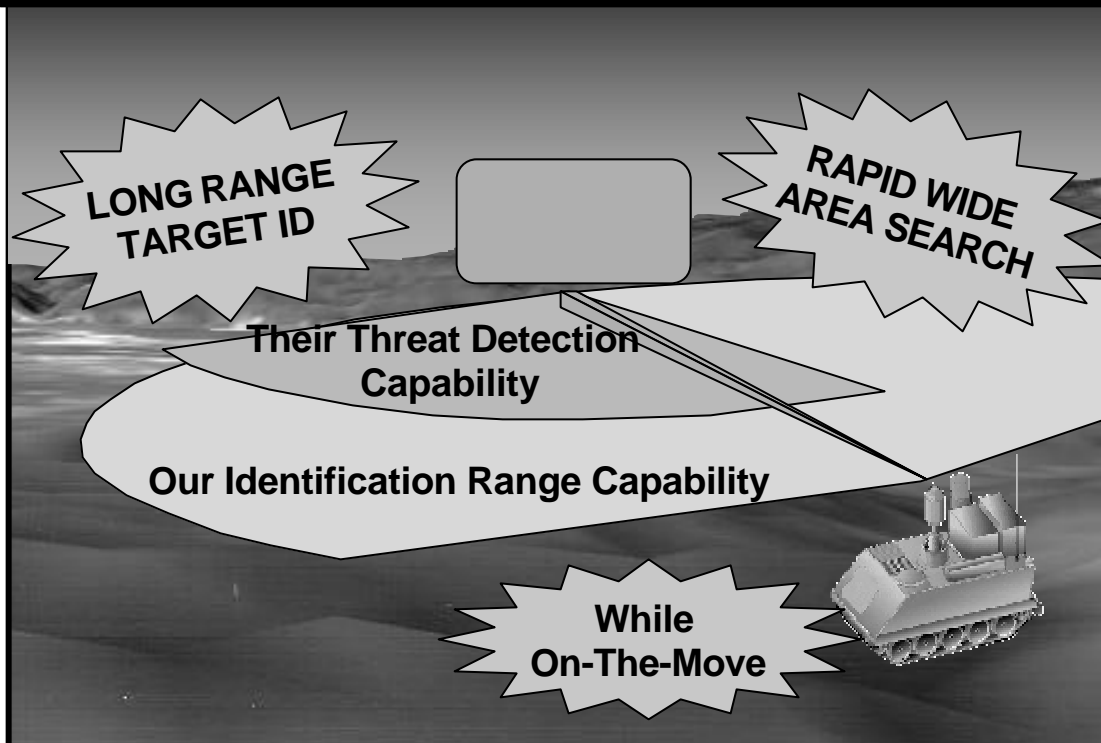
**MWIR improves ID range (1/D), but land forces (i.e. Army) unlikely to give up the advantages of LWIR (e.g. fog oil smoke and dust penetration)**



# Multifunction Staring Sensor Suite (MFS3) Advanced Technology Demonstration (ATD)



## *Future Combat Overmatch Capability:*



- *Multi Band Pathfinder for Third Generation Sensor*
- *Testbed for Performance and Cost Trade Offs*



## TECHNICAL APPROACH

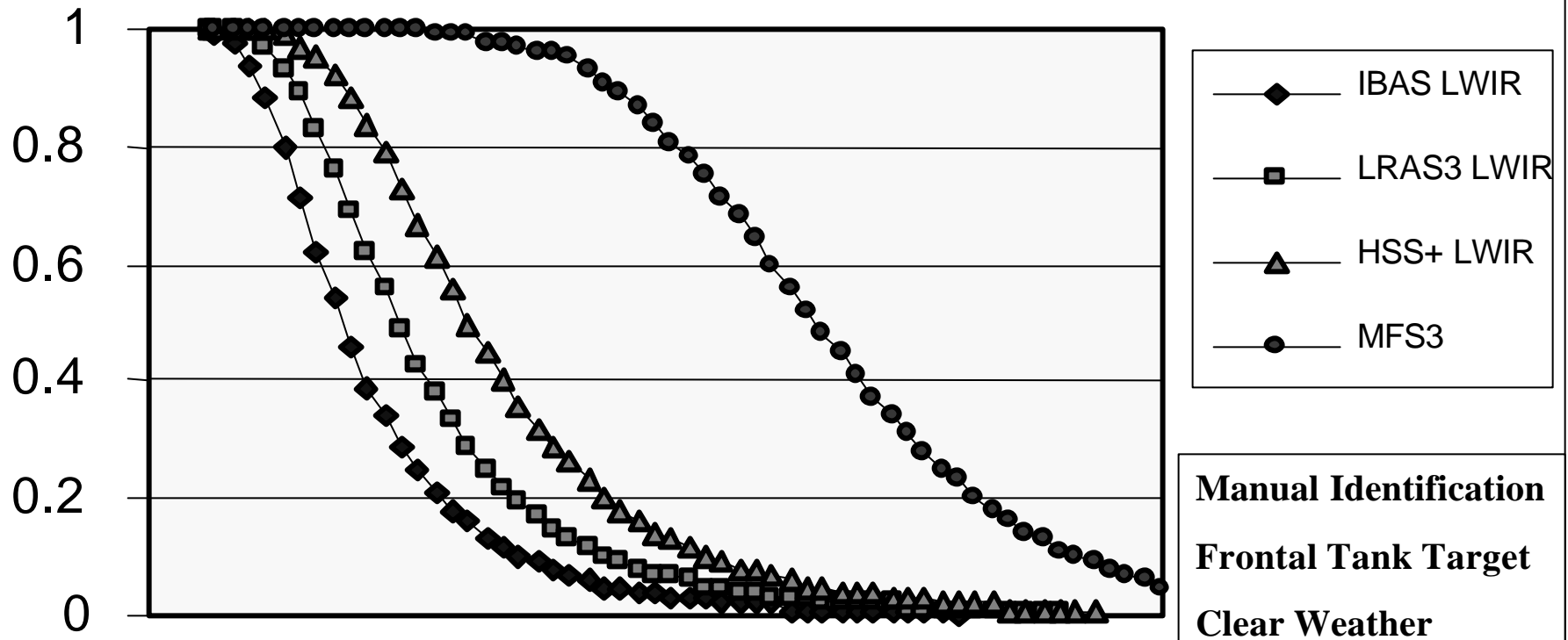
- Single 8" Aperture EO Suite  
Reflective, High f/#: 6.7
- 640x480 MCT Broadband Staring FLIR
- 4 Field-Of-View (FOV)
  - UNFOV:  $0.4^{\circ} \times 0.6^{\circ}$
  - NFOV:  $0.9^{\circ} \times 1.2^{\circ}$
  - MFOV:  $3.5^{\circ} \times 4.6^{\circ}$
  - WFOV:  $7.6^{\circ} \times 10.1^{\circ}$
- Eyesafe Laser Rangefinder / mapper
- Stabilized Line-Of-Sight
- De-rolled Image
- Field of Regard
  - Az: 360 Continuous
  - El: -20 / +180
- Acoustic Cueing (Army Research Lab)
- Automatic Wide Area Search  
High Rate Gimbal Scan
- ATR Algorithms  
Multi-Spectral Detection  
Shape Recognition w/ Laser  
Rangemapping



## Multifunction Staring Sensor Suite (MFS3) ATD Probability of Identification Comparison



### ***MWIR Provides Significant Passive Identification Range Advantage***



IBAS: 2nd Gen B-Kit, 5.5" Aperture, NFOV, 4x E-Zoom:  $0.5^{\circ} \times 0.67^{\circ}$

LRAS3: 2nd Gen B-Kit, 7.3" Aperture, NFOV, 4x E-Zoom:  $0.37^{\circ} \times 0.50^{\circ}$

HSS+: 2nd Gen B-Kit, 8.0" Aperture, NFOV, 2x E-Zoom:  $0.39^{\circ} \times 0.70^{\circ}$

MFS3: 640 x 480 MW Staring Array, 7.7" Aperture, UNFOV:  $0.42^{\circ} \times 0.56^{\circ}$



# MULTIFUNCTION STARING SENSOR SUITE (MFS3) ATD

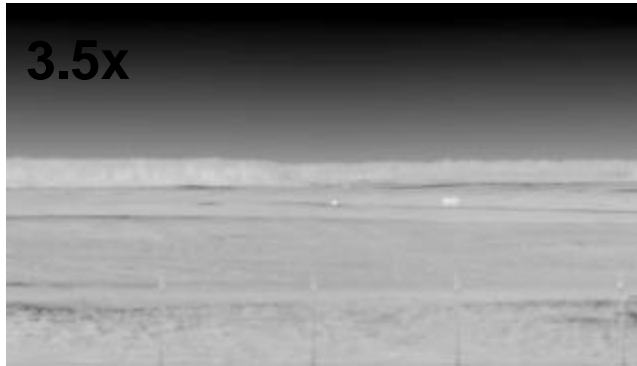
## Sensor Comparison



**Hunter Sensor Suite (HSS)**

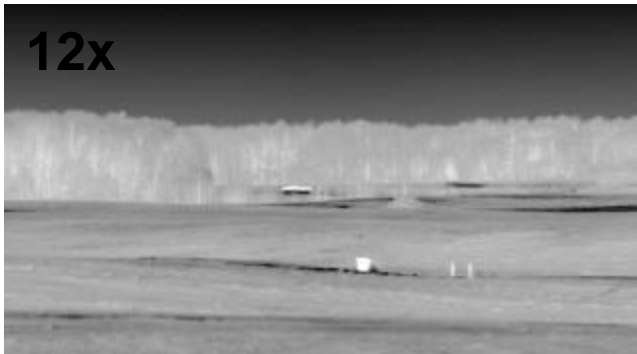
**HSS WFOV:**

**3.5x**



**HSS NFOV:**

**12x**



**Multi-Function Staring Sensor Suite (MFS3)**

**MFS3 WFOV:**

**2X**



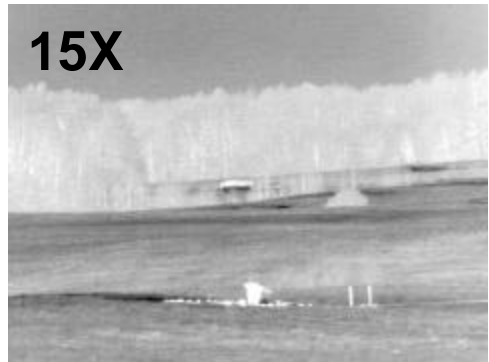
**MFS3 MFOV:**

**4X**



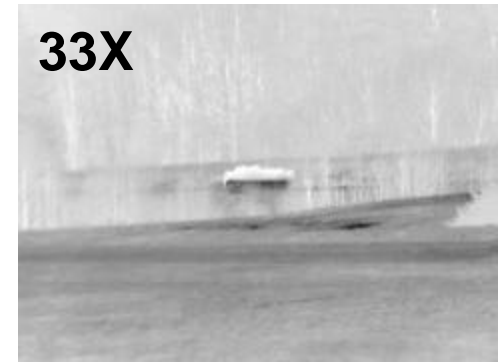
**MFS3 NFOV:**

**15X**



**MFS3 UNFOV:**

**33X**







# Uncooled IR Technology

## OBJECTIVES

Smaller Pixels/Increased Sensitivity  
Larger Formats (640x480)  
No Mechanical Chopper  
No Temperature Stabilization  
Lower Power  
Low Cost Optics

Leads To

## SENSOR PAYOFFS

Lower Cost  
Longer Autonomous Life  
Lighter Weight  
Smaller Volume  
Medium Performance

## APPLICATIONS

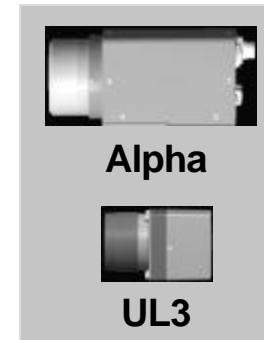
### New:

- Seekers / Munitions
- APLA
- UGS
- UGV
- Small/Micro UAVs
- Goggles for MOUT
- Head Tracker SA

### Lower Cost/Improved:

- Rifle Sights
- Driver Aides
- Physical Security
- Seekers

**Low Cost through Dual Use  
Commercial Volume**



Alpha

UL3

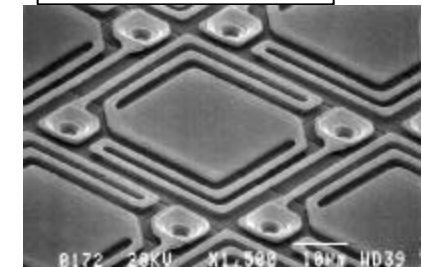


640 x 480  
Advanced Uncooled

## Baseline LOCUSP Sight



## DUAP Product



## Microbridge

Lower Logistics  
Costs



No more cryo-cooler -  
"lowest reliability  
component"

Low Performance Driven By Commercial Market -  $\leq 340 \times 280$   
Night Imaging < \$1K for the First Time, New Applications

Medium Performance (640x480 small pixel) Enables  
Affordable Sensor Suites (with Eyesafe Laser Illuminators for ID)



# Technology Commercialization

## A Shift in Paradigm for Uncooled IR



### Military Investment

- DARPA
- Army
- Other

### Driving the Technology

- Small pixels
- Improved Sensitivity
- Larger Arrays

### Bethesda-Chevy Chase Rescue Squad, Inc.

5020 Battery Lane • Bethesda MD • 20814



Thermal  
Imaging  
Camera Saves  
Ricky....

Ricky, a 10-year-old Labrador Retriever, was rescued from a burning house in Bethesda, Maryland, after a fire on Monday, April 14, 1999. The fire was caused by a faulty electrical outlet. Ricky was rescued by the Bethesda-Chevy Chase Rescue Squad, Inc. after a fire on Monday, April 14, 1999.



Raytheon Introduces "COP" FLIR

### Commercial Sector Provides Volume for Components



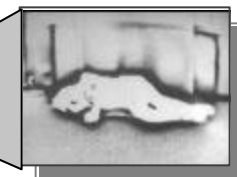
Raytheon Marine  
FLIR for Navigation

Use of low cost  
commercial cameras



Military Sensors  
at reduced cost

Medium performance  
military arrays built  
on commercial fab



**Firefighters Set to Get High-Tech Helmets**

*The Washington Post 1 April 1999*

NVESD Has 6 DUAP / DUST Programs to Drive Technology to This Goal !

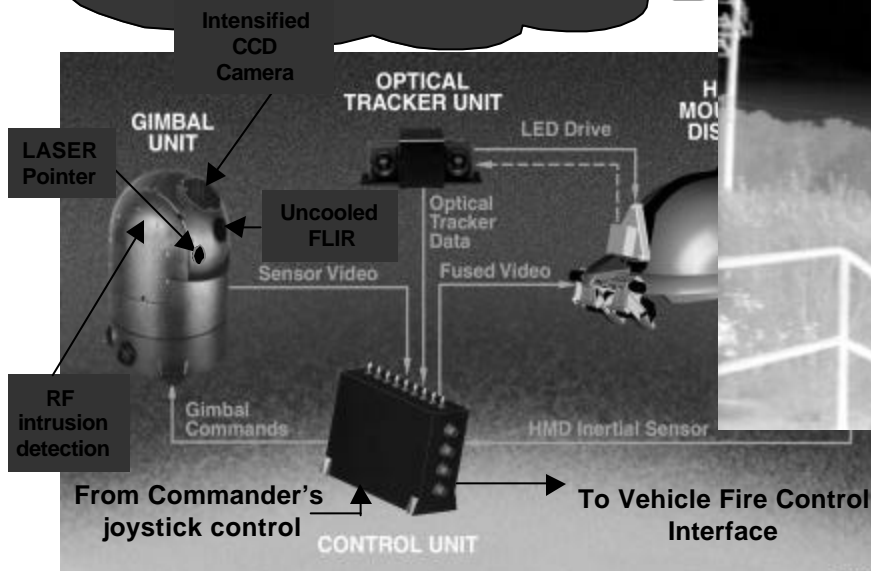
**Commercial Volume is Key for Affordable Military Applications**



# Commander's Head Tracked Sensor Suite (CHTSS)

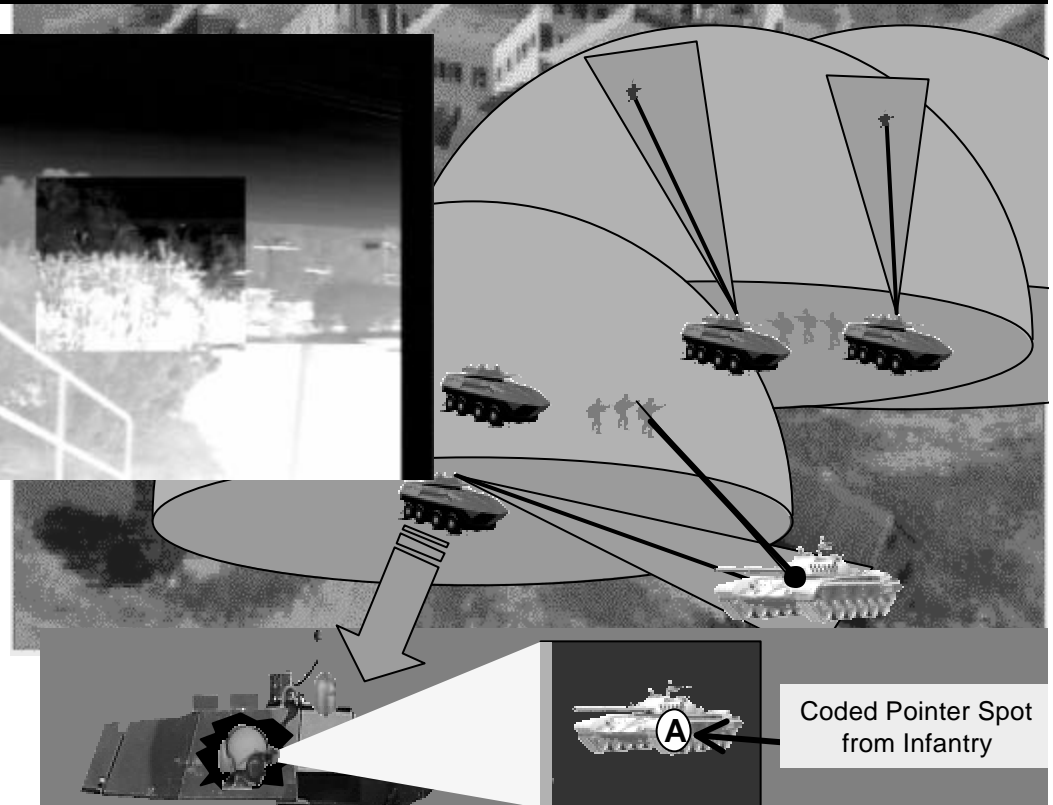


*All around near-vehicle SA  
at significant cost reduction for  
protection from dismounted  
attack-an Infantry School high priority*



## **Commander's HT Viewer Suite for 360° x 90° SA and Connectivity.**

- Uncooled Gen 3 FLIR
- Intensified Gated CCD camera
- High power pointer with cooperative ID



## **Closed Hatch Connectivity -w- Dismounted Infantry**

The CHTSS provides an affordable 360° (h) X 90° (v) dome of situational awareness, protection and target acquisition to brigade vehicles, especially in closed hatch and night time operations in difficult operational scenarios.

- Supports mounted operations in open terrain and dismounted infantry operations in urban fights.



# Cost Effective Targeting System (CETS)

**Role of System:** Affordable targeting system for mid tier performance OF platforms, e.g. UGVs and Troop Carriers, and Crew Served Weapon applications

**Approach:**

- Utilize large format (640 x 480) 1 mil pixel uncooled FLIR for search, target detection and cueing of high resolution Short Wave Infrared (SWIR) camera.
- Exploit technology advances in higher resolution SWIR gated camera coupled with low cost, covert, eyesafe, micro laser rangefinder / illuminator to provide long range target ID range performance (>3km in reasonable weather).
- Search with Uncooled FLIR (w/ATR for UGV), LRF pulse to set camera gate and beam divergence, illuminate target for high res SWIR image for operator ID

**Advantages:**

- Uses short wavelengths to ID targets at long range with smaller apertures
- Affordability - Estimated <\$50k/system w/o vehicle integration
- Modest stabilization - Laser pulse freezes target
- No FLIR cooler
- Class I Eyesafe

Unmanned Ground Vehicle (UGV)



Troop Carrier



Crew Served Weapon



Uncooled FLIR (for search) plus Eyesafe Flash Laser Illuminator (for ID)



# ***Conclusions***

## ***For extended red and beyond***

- LWIR Gen II (MCT) big success – excellent imagery with good smoke and dust penetration
- Staring MWIR (mostly InSb) being implemented on air platforms (include UAV) and hand held designators (LLDR)
  - Better resolution with a constrained aperture but more sunlit clutter
- Looking forward to Gen II++ for OF – rapid search (ATR) and longer range ID with active imaging to overcome ROE asymmetry
- Future Gen III (dual band/multicolor) provides *passive*, on the move, rapid wide area search and difficult target acquisition at extreme ranges.

## ***For the close in fight***

- Uncooled Technology is coming on strong with many commercial applications
  - Sensors proliferated across the battlefield
  - Long term challenge to U.S. superiority

Challenge is providing affordable sensor solutions and still meeting user needs.

***See First - Understand First - Act First - Finish Decisively***